the Ustilagineæ. The two groups have little in common, and it must not be supposed that their association in this work implies any near relationship between them. The bond of union is rather to be found in their common biological character as more or less injurious parasites.

In Chapter VIII., the mycelium of the Ustilagineæ is described, and attention is specially called to the fact that it usually spreads throughout the tissues of the host-plant, thus differing from the localized mycelium of most Uredineæ.

The next chapter treats of the development of the "teleutospores" (resting-spores) of the Ustilagineæ. The singular processes by which the "spore-balls" arise in such genera as Soroporium, Tubercinia, and Urocystis are clearly described in accordance with the researches of von Waldheim, Woronin, de Bary, and others. The facts are not, as a rule, new, but they are well put together. The germination of the teleutospores is described in the following chapter. The extraordinary processes of conjugation, in which both the promycelium itself and the sporidia so often take part, are described; and due weight is given to Brefeld's important discovery that these cell-unions do not take place when the spore is allowed to germinate in a food-solution, instead of in pure water. There are many points here which invite more detailed notice, but this may be the better dispensed with, as most of the facts have already been brought before English readers, in the translation of de Bary's work and in some of Prof. Marshall Ward's papers.

The subject of Chapter XI., the infection of the host-plants by the Ustilagineæ, is of great practical interest. In the case of the bunt (*Tilletia tritici*), it is well known that the sporidia borne on the promycelium of the teleutospores infect the embryo of the germinating grain, the germ-tubes penetrating the cells of the leaf-sheath. But how smut (*Ustilago segetum*) infects wheat has long been a mystery. The spores ripen in the young flowers, and have disappeared long before the grain is mature. Attempts at infection of the grain or seedling are almost always unsuccessful; and, on the other hand, the protective dressings of the grain, which are so effectual against bunt, are of no avail as against the attacks of smut. The experiments of Jensen render it most probable that the plant is infected by the spores while flowering, and that either the ovum itself is entered by the mycelium, or that the spores remain dormant in the grain until its germination, and that then the parasite "grows with the growth, and strengthens with the strength" of the young plant. It would appear, then, that the only remedy against the attacks of the Fungus would lie in the destruction of all affected ears at the earliest stage when the disease is visible, and before the spores have ripened.

The last two chapters of the introduction are among the most interesting to specialists, but do not require any analysis here. They deal with the culture of spores, and with the artificial infection of plants. Under the latter head it may be noted that only the Uredineæ are taken into account. The directions given are those of a master of the subject, and cannot fail to be a most useful guide to those who intend to undertake such investigations for themselves.

The longest, and no doubt the most valuable, part of the work consists in the description of all British species of the two families; pp. 119–271 being devoted to the Uredineæ, and pp. 272–301 to the Ustilagineæ. Attention has already been called to the admirable biological notes by which the descriptions of all the more important species are accompanied. In the specific diagnoses, the æcidiospores (when present) are first described; then the uredospores, and, lastly the teleutospores. Next follows a complete list of synonyms, and then the host-plant or plants are enumerated, after which the biology of the species is discussed. The account of the Ustilagineæ is completed by the description of a few genera, such as Graphiola and Protomyces, of doubtful systematic position.

A glossary is appended to the work, and in some of the explanations of terms there is room for criticism. Thus, in defining *conidium* as "an asexual spore," it seems to be too easily assumed that the other spores are sexual. The word *endochrome* is no longer required, and might perhaps be allowed to become obsolete. A *germ-pore* is not an "opening," but a pit, and a *hypha* does not necessarily consist of "an elongated cell." The word *periblem* means the young cortex itself, not "that part of the root of the host-plant which lies beneath the cortex," while *sterigma* is certainly *not* "the same as basidium."

The eight plates contain a great number of good figures, many original, others taken from the works of de Bary Brefeld, Woronin, &c.

A list of the authors quoted is given, and the book is especially well provided with indices, which are three in number. The first, a very useful one, gives the names of all the host-plants of the Uredineæ and Ustilagineæ respectively. Then we have a general biological index; and, lastly, an index of species, including all the synonyms.

The book is exceedingly well got up, but we must protest against the vivid yellow of the cover, presumably intended to recall the colour of the uredospores! Perhaps the decorous brown of the teleutospores would have been more becoming if symbolical colouring was wanted.

D. H. S.

THOMAS ANDREWS.

The Scientific Papers of the late Thomas Andrews, M.D., F.R.S., Vice-President and Professor of Chemistry, Queen's College, Belfast. With a Memoir by P. G. Tait, M.A., Sec. R.S.E., and A. Crum Brown, M.D., F.R.S., Professors in the University of Edinburgh. (London: Macmillan and Co., 1889.)

WE have here in a compact form the biography and scientific works of a man who has left his mark on the science of his time.

Born at Belfast in 1813, Thomas Andrews after acquiring the rudiments of his education at two excellent public schools in his native town, went at the age of fifteen to the University of Glasgow, where he attended the classes of chemistry and natural philosophy for one or two sessions; and in the following years he continued his studies at Paris, Dublin, and Edinburgh, taking the degree of M.D. at Edinburgh in 1835. He immediately began to practice as a physician at Belfast, and also to teach chemistry as Professor in the Belfast College, which was a higher department of the Belfast Academical Institution. In 1845, the scheme for the creation of the Queen's Colleges was launched, and their Presidents and Vice-Presidents were appointed as a preparatory step to the building of the Colleges. Andrews at this time received his appointment as Vice-President, and he was the first Professor of Chemistry, both which offices he retained till the failure of his health in 1879. His whole life-time was thus—with the partial exception of his medical practice from 1836 to 1845—occupied in scientific teaching and investigation; and from the early age of fifteen, when he published in the *Philosophical Magazine* a paper on the action of a blowpipe flame on other flames, he never ceased to devote himself to original research.

He was never in a hurry to rush into print, but took care to be accurate and thorough in an investigation before announcing his results. Regularly day by day he was to be found at work for hours in his laboratory, patiently conducting with his own hands every detail of his elaborate observations.

The most important of his researches relate to heat of combination, the nature and properties of ozone, and the transition of such substances as carbonic acid from the gaseous to the liquid state. But besides these, we find in the present collection brief papers on a variety of subjects. One contains an account of experiments on the conducting power of flame for electricity, showing that the current from a single cell could be transmitted through a circuit part of which consisted of an alcohol flame. Another describes the attainment of a very high vacuum by a good ordinary air-pump aided by the introduction of carbonic acid into the receiver and the absorption of the last traces of this gas and of aqueous vapour by caustic potash and sulphuric acid. Another gives a comparison of the conducting powers of different gases for heat, as shown by their cooling action on a platinum wire kept incandescent by a current. In all these subjects he was early in the field, and obtained results much in advance of those obtained by his predecessors.

An instance of his careful criticism is afforded by one of the latest papers in the volume—a lecture on recent improvements in magneto-electric machines—in which he points out that Paccinotti's machine, if the inventor's original description of it can be relied on, makes its contacts (for collecting the currents from the ring) in the wrong places. The criticism is certainly justified by the figure and accompanying description which are reproduced from Paccinotti's paper; but from inquiries which we made at the Paris Electrical Exhibition, where the machine was on view, we believe the fault was in the description and not in the machine itself.

As regards ozone, Andrews appears to have been the first to establish the following points:—

(1) That the peculiar substance obtained by the action of the electric spark on oxygen is identical with that obtained in the electrolysis of water, and with that obtained in the slow oxidation of phosphorus.

(2) That it is not a compound body, but is oxygen in an altered or allotropic condition.

In subsequent experiments, with the assistance of Prof. Tait (who was at that time Professor of Mathematics in Belfast), he compared the amount of contraction produced by the partial conversion of oxygen into ozone with the amount of ozone thus obtained as tested by chemical action, and hence deduced the density of ozone.

His researches in various branches of the subject of heat of combination were spread over many years, and were, for the most part, conducted at a date when an accurate thermometer for measuring small differences of temperature could only be obtained by making it for oneself. The subsequent researches of Favre and Silbermann, wherever they differed to any large extent from his, have since been shown to be erroneous, and his results agree fairly well with the latest and best determinations yet obtained.

But his permanent fame will rest mainly on his discovery of the continuous transition which can be made from the gaseous to the liquid state of a substance, or from the liquid to the gaseous. The main result which he established is best set forth by the geometrical illustration employed by his colleague, Prof. James Thomson. Let the volume, pressure, and temperature of a given mass of carbonic acid be represented by the three rectangular co-ordinates of a surface; volume being represented by height, while the pressure and temperature co-ordinates are horizontal. The surface will resemble the side of a mountain which is precipitous in one part, but in another part furnishes a gradual ascent by which the summit can be reached. The ground-plan of the precipice is the curve of boiling-points, and the height of the precipice at each point of the curve represents the increase of volume in passing from the liquid state to the gaseous. As the temperature increases, the precipice diminishes in height, and finally runs off to nothing at a point whose horizontal co-ordinates are the "critical temperature" and "critical pressure." At higher temperatures there is no boiling-point, and in place of the precipice there is a gradual ascent, by means of which the precipice can be rounded and the summit attained. Starting from the ground below the precipice (that is, from the liquid state), the ground above the precipice (that is, the gaseous state) can thus be attained without any kind of discontinuity.

Cagniard de Latour and Drion, who preceded Andrews in this field of research, failed to obtain this result, because their method of experiment placed only one independent variable at their disposal. The substance was inclosed in a sealed tube, and there was no way of altering its pressure except by altering its temperature. Andrews used a screw plunger, which enabled him to increase and diminish the volume independently of the temperature. By making simultaneous measures of volume, pressure, and temperature for various values of the two independent variables, he was able to map out the surface, and Prof. J. Thomson constructed a wooden model of it from the data thus obtained.

In subsequent researches he investigated the effect of mixing various quantities of nitrogen with carbonic acid, and found that the critical point was largely shifted by such admixtures.

Shortly before his health broke down, he devised an ingenious apparatus for making successive additions of a known column of mercury to the pressure of a gas confined in a long tube, hoping in this way to be able to test departures from Boyle's law at very high pressures without employing a column of mercury of unwieldy length. In the reference to this subject in the preface there appears to be an oversight. The effect of a certain cycle of operations to be performed with the apparatus is described and then we read:—

"A connected series of vessels of this kind will enable the experimenter to apply a measured pressure of an amount depending on the number of vessels."

Instead of a connected series of vessels, it is only necessary to repeat, time after time, with the one vessel, the cycle of operations which has been described; and this we understood to be Dr. Andrews's intention. The apparatus was not brought into actual use, nor even constructed; preliminary trials having shown that screw plungers working in mercury (which were an essential part of the design) could not be prevented from leaking.

The various papers in this volume, and especially the Presidential Address, show Dr. Andrews to have been not only an accurate and original worker, but a man of wide culture and refined literary taste. The editors have done their work carefully and well. J. D. E.

MACH'S "HISTORY OF MECHANICS."

Die Mechanik in ihrer Entwickelung historisch-critisch dargestellt. (An Historical and Critical Sketch of the Development of the Principles of Mechanics.) By Dr. E. Mach, Professor of Physics in the University of Prague. Second Edition. (Leipzig: F. A. Brockhaus, 1889.)

THE first edition of this work, which forms Vol. LIX. of the "International Scientific Series," appeared in 1883. With the exception of a few short appendices and the correction of misprints, it is identical with the original edition; but we are glad to take the present opportunity of calling attention to a book which, while unpretentious in form, is one of exceptional value to students, and especially to teachers, of the subject with which it deals.

The book has not been translated into English, and we understand that the English publishers did not consider it sufficiently popular in form to be included in the English series. This is much to be regretted. The work is one which certainly ought to be translated, as it would be most helpful to a large class of students and teachers who are unable to read it in German.

In the course of rather fewer than 500 pages the author gives his readers a well-constructed outline of the development of the science of mechanics from Archimedes down to the present time, accompanied by well-reasoned criticisms and discussions of the significance and relative importance of the various steps which he chronicles. The first chapter is devoted to the development of the principles of statics, and we would specially direct attention to the masterly manner in which the author shows the fallacies underlying the attempts of some of the early philosophers to derive the principle of the parallelogram of forces, or an equivalent one, from *a priori* notions, without appeal to experiment. The proposition commonly known as the parallelogram of forces may either be proved by direct experiment or by deduction from some such experimental principle as Newton's second law of motion. The advantage of the latter method consists, as the author points out, in the fact that he nature and extent of the experimental evidence for Newton's second law, or its equivalent, cause it to carry with it a greater certainty of its accuracy than is possible for a direct experimental demonstration of the proposition. This is a point to which it is most important to call attention, for, although Thomson and Tait have long since cleared away from the better class of text-books, and from the minds of the higher class of students, the fog which had accumulated around this essentially simple proposition, much of our school teaching is still enshrouded by it.

The second chapter treats of the growth of the principles of dynamics, understanding this in the more restricted sense of what Thomson and Tait called kinetics. This is of great interest and value throughout, but there are one or two points to which we would direct special attention.

The deduction of the approximate time of swing of a simple pendulum vibrating in a small arc, from a rectilinear simple harmonic motion, is, or at any rate should be, well known to students who have had the advantage of instruction from a Professor at one of our Universities; but it is quite time that this very simple method of obtaining an important relation should take the place of the artificial and cumbrous methods which still disfigure some of the elementary text-books in common use. The criticism of Newton's exposition of the ideas of time, space, motion, and mass, is also worthy of careful study. These two chapters are of quite an elementary character, and may be read with advantage even by students whose mathematical acquirements are of the slenderest.

The third chapter treats of the further application of principles, and the deductive development of mechanics. It does not, like the first two chapters, appeal to the beginner, but will be most helpful to a student who has already made some progress in the subject.

The fifth chapter bears the heading, "The Formal Development of Mechanics." It contains an interesting discussion of isoperimetric problems, and a brief account of the analytical method of treatment introduced by Lagrange. It also contains a section mainly devoted to an account of the theological vagaries of some of the great mathematicians and natural philosophers. This section is not of very great interest or value, and may have been inserted merely to give a popular flavour to what is essentially a scientific book.

The volume concludes with a very brief chapter on the relations of mechanics to other branches of knowledge.

G. W. DE T.

OUR BOOK SHELF.

Das Klima des ausser-tropischen Südafrika, mit Berücksichtigung der geographischen und wirtschaftlichen Beziehungen nach klimatischen Provinzen dargestellt. Von Dr. Karl Dove. 160 pp. and 3 charts. (Göttingen: Vandenhoeck and Ruprecht, 1888.)

METEOROLOGISTS must welcome the reappearance of the name of Dove among the contributors to climatological knowledge, and the present work does no discredit to the name. It is an endeavour to give a conspectus of the climate of South Africa as a whole; and the author ekes out the actual meteorological results, which are somewhat scanty in parts, by evidence derived chiefly from the indigenous flora of the several districts, which